PATENT SPECIFICATION

DRAWINGS ATTACHED

1,071,191

1,071,19

Date of Application and filing Complete Specification: April 23, 1964.
No. 16855/64.

Two Applications made in United States of America (Nos. 333085 and 333057) on Dec. 24, 1963.

Complete Specification Published: June 7, 1967.

Index at acceptance:—**D1** R3; **A3** V(1B3B, 7BX); **A5** R(83A, 83H); **B5** N(17Y, 22X, 22Y, 35Y, 69X, 71X, 175, 177, 178, 238, 250, 252X, 253X, 254X, 262X, 270X, 280X, 2 300X, 301X, 303X, 304X, 319, 320, 322X, 326X, 336, 344, 345, 348, 353, 355, 386, 626, 627, 653, 654, 656, 670, 678, 682, 691, 715, 752, 758, 765, 773, 805); **D1** L(23A, 23D, 23F, 23X)

Int. Cl.:—D 04 h//A 41 b, d, A 61 l, B 32 b, D 06 b

ERRATA

SPECIFICATION No. 1,071,191

Page 2, line 122, *for* "or" *read* "of"
Page 3, line 3, *after* "it" *insert* "is"
Page 3, line 42, *for* "eucalytus" *read* "eucalyptus"
Page 3, line 111, *for* "through" *read* "though"
Page 5, line 25, *for* "or" *read* "of"
Page 6, line 66, *for* "the" *read* "a"
Page 7, line 30, *for* "especi" *read* "especially"
Page 7, lines 48 and 49, *after* "repellent" *delete* "on"
Page 8, line 77, *for* "scren-belt" *read* "screen-belt"
Page 8, line 121, *for* "4.5%" *read* "0.5%"
Page 10, line 33, *for* "an" *read* "and" (first occurrence)

THE PATENT OFFICE
18th June 1968

in the industry as "dusting" or "linting". Furthermore, the assemblages have little strength, poor cohesive stability, are difficult to handle and process and virtually impossible to use without the incorporation or addition of other components. For example, to provide strength the short-fiber assemblages may have incorporated therein a gauze or paper

and mechanically inter-engaged non-cardable fibers having a length not in excess of 1/4 inch, with or without longer fibers, said fluffy batt being flimsy and incapable of being handled without fiber separation in the absence of a binder, and an adhesive bonding material distributed through the fibers at one or both surface layers of the batt on the surface of individual fibers but not ex-

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Int. Cl.: —D 04 h//A 41 b, d, A 61 l, B 32 b, D 06 b

COMPLETE SPECIFICATION

Absorbent Non-woven Fibrous Product

We, JOHNSON & JOHNSON, a Corporation of the State of New Jersey, United States of America, of 501 George Street, New Brunswick, New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to absorbent non-woven fibrous products, and more particularly to absorbent fibrous structures having the surface fibers adhesively bonded whereby the entire product is stabilized and given strength and is suitable for use as a sanitary napkin, disposable diaper, surgical dressing, underpad, and the like and to methods of making such a product.

A major absorbent material used in the manufacture of products such as sanitary napkins, disposable diapers, dressings, and the like, is an assemblage of short fibers such as batts or layers of comminuted wood pulp, cotton linters or other non-cardable short fibers. The non-cardable short-fiber assemblages are fluffy and flimsy, have good absorption qualities, are usually of low cost and are readily available. A major disadvantage of such non-cardable short-fiber assemblages is that the short fibers readily separate from the general assemblage. This property is commonly known in the industry as "dusting" or "linting". Furthermore, the assemblages have little strength, poor cohesive stability, are difficult to handle and process and virtually impossible to use without the incorporation or addition of other components. For example, to provide strength the short-fiber assemblages may have incorporated therein a gauze or paper reinforcing layer or to provide strength and reduce "dusting" the assemblage may be wrapped in a casing or cover of paper, gauze, nonwoven fabric or the like. The added components, though increasing strength and reducing "dusting", have the disadvantages of increasing the cost of the final absorbent product and also in changing some of the favorable properties of the short-fiber assemblage such as absorption and hand.

Attempts have been made to eliminate the necessity of incorporating another component with or in the non-cardable short-fiber assemblage and yet give the assemblage the required stability. For example, compressing the non-cardable short-fiber assemblage at specific areas to fuse or bond the fibers in these areas or by incorporating in the assemblage heat- or solvent-activatable fibers which when activated fuse and bond to produce stability in the assemblage. However, none of these methods has met with great acceptance not only for economic reasons but also because they change the absorption properties, fiber-density properties, the properties of hand and softness and other properties of the non-cardable short-fiber assemblage.

The present invention provides a unitary, fluid-absorbent product comprising a fluffy batt of randomly arranged, intermingled and mechanically inter-engaged non-cardable fibers having a length not in excess of 1/4 inch, with or without longer fibers, said fluffy batt being flimsy and incapable of being handled without fiber separation in the absence of a binder, and an adhesive bonding material distributed through the fibers at one or both surface layers of the batt on the surface of individual fibers but not ex-

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SEE ERRATA SLIP ATTACHED

tending into the interior of the batt to a depth greater than 25% of the total thickness of the batt, thereby converting the respective surface fibers into a relatively strong skin comprising discontinuous binder originally applied to the batt as a foam with binder-coated fibers joined by binder at their intersections, said skin being mechanically locked to the unbonded interior portion of the batt by those fibers lying partially in the unbonded interior and partially in the unbonded surface portions of the batt, the batt and skin thus constituting a self-sustaining, relatively strong handlable structure.

Preferably the adhesive bonding material is distributed in a predetermined pattern of spaced binder areas.

Advantageously the product includes a thin layer of fibers longer than 1/4 inch on at least one surface of the batt, the bonding material being distributed in the part of the product in which it is present both throughout the short fibers and the longer fibers.

A layer of fibers longer than 1/4 inch may be provided in the interior of the batt. Preferably the batt has a thickness of at least 1/16 inch.

Generally the adhesive bonding material comprises 0.1% to 10% based on the weight of the absorbent product, and the skin has a thickness of less than 25%, and preferably between 1% and 10% of the total thickness of the batt.

Preferably the fiber layer in the skin is not densified to any substantial extent and the binder is porous throughout its surface.

According to one embodiment of the present invention the skin is formed on one surface of the product while a water-repellent material is distributed throughout the fibers on the opposite surface but not through the interior of the batt.

According to an alternative embodiment of the present invention a water-repellent material is laminated to one surface of the batt whereby the batt has an absorbent surface and a water-repellent opposite surface.

One product in accordance with the present invention is in the form of a self-sustaining sanitary napkin having compressed longitudinal edges to limit leakage of fluid and having means for attaching it to the body.

The stable fiber assemblages of the invention have cohesive strength, good absorption characteristics, and do not "dust" or "lint". Fibers do not "pick" or "pill" from the surface of the stable fiber assemblage and the surface is resistant to abrasion.

The non-cardable short-fiber assemblages of the present invention are self-sustaining and may be used by themselves as absorbent products or in combination with other materials such as water-proof paper, plastic films and the like. If desired, the stable assemblages of the present invention may be wrapped in gauze, non-woven fabric or similar materials for use in areas where considerable strength is required or to improve the adaptability of the product to the body. For example, sanitary napkins generally have an absorbent bulky center section with pinning tabs extending beyond the ends of the absorbent material for holding the absorbent material when in use. A simple and economical sanitary napkin could readily be formed by wrapping a stable short-fiber assemblage of the present invention, having the desired size and shape, in a piece of gauze fabric which extends beyond the ends of absorbent material to form the pinning tabs of the sanitary napkin.

The stable non-cardable short-fiber assemblages of the invention may be produced by applying small amounts of adhesive bonding materials to the surfaces of fibrous batts. In accordance with the process of the present invention this is done by applying the bonding material in the form of a foam to one or both surfaces of the fluffy batt in a manner to limit penetration of the bonding agent to the said surface or surfaces whereupon the bonding material is subjected to drying while in the surface of the batt. The foam is light and does not compress the batt. The foam seeps in and around the surface fibers without substantially soaking the fibers and the light foam does not disrupt the general fiber arrangement of the batt. After being applied to the surface fibers the foam cells break and the foam starts to dry to form an adhesively bonded, self-sustaining skin of fibers and bonding material on the surface of the batt without substantially disrupting fiber arrangement and fiber density in the interior of the batt.

The skin of fibers and bonding material on the surface of the batt is integral with and a unitary part of the entire batt and gives cohesiveness and strength to the non-cardable short-fiber batt and prevents the separation of fibers from the batt.

The following is one method of making this product.

A foamed bonding material is carried on a moving surface and transferred from the moving surface to the surface of a fluffy batt of randomly arranged, intermingled and interengaged fibers moving in proximity to the surface carrying the foamed bonding material. The foam bonding material penetrates the surface of the batt and is dried in the surface to form a skin or fibers and bonding material which stabilizes the entire batt and forms a self-sustaining absorbent product.

The moving surface used to carry the foamed bonding material may be solid, flexible, patterned or unpatterned, for example. Suitable surfaces are, for example a smooth roll, flexible belt, embossed roll or perforated drum. Depending on the type of surface used

the foam bonding material may be applied in an overall pattern or in an intermittent pattern of spaced binder areas. If it desired to place the foam material in an overall pattern the foam may be applied to the surface of a smooth roll and transferred from the roll to the surface of the batt or the foam may be applied to a screen belt, woven with wide openings, and the foam allowed to pass through the belt onto the surface of the fibrous batt. If it is desired to place the foam material on the surface of the batt in a predetermined pattern the foam may first be applied to a roll embossed in the desired pattern and transferred from the embossings to the surface of the fibrous batt or the foam material may be applied to the inner surface of a perforated drum and passed through the perforations onto the surface of the fibrous batt.

If the foam material is applied in a predetermined pattern it is preferred that the spacing between binder areas be less than the average length of fibers in the fibrous batt.

It is important that the surface carrying the foamed material and the batt to which the foamed material is applied move without relative translatory motion with respect to each other so that the fiber arrangement in the batt is not substantially disrupted and the batt maintains its softness and absorption characteristics.

Care is taken to separate the surface carrying the foam material and the fibrous batt while the foam is still reasonably moist to reduce the possibility of fibers sticking to the surface carrying the foam material.

In general the starting material may comprise a batt, sheet, layer or other various shaped mass of non-cardable short fibers such as, for example, wood pulp, cotton linters, jute, linen, hemp, manila, bamboo, eucalytus, bagasse, straw or esparto. Any of the various types of wood pulps may be used, such as mechanical wood pulp, chemical wood pulp, semi-chemical wood pulp or reclaimed paper pulps. The pulp may be manufactured from any of the various coniferous or deciduous trees such as hardwood, hemlock, fir, pine, gum poplar, and the like. The cellulosic fibers are preferred because they are inexpensive, readily available and highly absorbent. Other non-cardable short fibers or blends of fibers may be used, such as wool, nylon, cellulose acetate, Viscose (Registered Trade Mark) rayon, and the like. Non-cardable short fibers have a length not in excess of 1/4 inch. The fiber length may vary downwardly from 1/4 inch to a few hundredths of a millimeter or less, e.g., some of the more common wood pulps contain fibers ranging in length from about 0.5 mm. to 6 mm. with most of the fibers in the wood pulp having a length of from about 1 mm. to 3 mm.

Virtually any of the known adhesive bonding materials which are foamable may be used to bond the fibrous batt. Suitable bonding materials are, for example, the acrylic resins, such as the polymers and co-polymers of the lower alkyl esters of acrylic acid, for example, ethyl acrylate; the formaldehyde condensation products such as urea-formaldehyde, melamine-formaldehyde and phenol-formaldehyde; the vinyl resins such as vinyl acetate resins and vinyl chloride resins; the polyolefins such as polyethylene, polypropylene and polyisobutylene; the styrene resins; the polyurethane resins; the synthetic and natural rubbers; the cellulosic materials such as Viscose (Registered Trade Mark) hydroxyethylcellulose; the starches; and the natural glues such as gum arabic.

The adhesive bonding materials used in accordance with the present invention are dispersions or solutions of the above-mentioned polymers, co-polymers and other chemicals. The dispersions used are generally aqueous and the solutions may be aqueous or non-aqueous. Aqueous mediums are preferred because of their ease of handling, non-toxic nature, etc.

The solutions and dispersions are foamed by adding surfactants or wetting agents which lower the surface tension of the liquid and then introducing air or other gas under the surface of the liquid mass, for example, by agitating the surface of the liquid, so that the liquid encases the air and forms a foam.

Suitable surfactants are the alkyl-aromatic sulfonates, fatty alkyl sulfates, sulfated oils, sulfated esters, petroleum sulfonates, carboxylic acid soaps, quaternary ammonium compounds and amine salts. Specific surfactants suitable for producing foam are dodecyl-benzene-sulfonate, sodium stearyl-sulfopropionate, lauryl alcohol sulfonate, monostearyl-ethylene-diamine and trimethyl- ammonium methyl sulfate. The amount of surfactant used may be varied over wide limits of from 0.1% to 5% based on the weight of resin used, through it is preferred that from 0.5% to 2.5% of surfactant be used in producing the foamed resin.

It is important that the foam bonding material to be applied to the fiber base be fresh and not allowed to stand. If the foam bonding material is allowed to stand for a long period of time foam cells break and the foam starts to separate producing areas of increased wetness rather than a uniform foam. Such non-uniform foams are tacky and are difficult to apply in a predetermined pattern of spaced areas. If the foam is too wet the fibers become saturated with water and the fiber assembly will become compressed and densified in the wet areas.

The wetness of the foam will depend to a large extent on the amount of bonding material solids in the liquid to be foamed, the type and amount of surfactant used, the

ratio of air or other gas to liquid, foam-cell size, etc. For example, a foam made from a liquid with high resin solids using an air-to-liquid ratio of 20 to 1 with a fine cell size would produce a dry foam which would only slightly penetrate the fibrous batt whereas a low-resin-solid liquid foamed with 5 parts of air per part of liquid with a cell size of 1/8 inch would produce a wet foam. Foams made from liquids having a solids content of about 5% with an air-to-liquid ratio of 10 to 1 have been found suitable for use in accordance with the present invention.

It is preferred that the foam bonding material have a foam-cell size of less than 1/8 inch diameter and preferably less than 1/16 inch diameter. Foams having a cell size of 1/40 inch down to 1/100 inch diameter have been found suitable for use in accordance with the present invention. The fine-cell foams are stable and easily controlled both as to uniformity of foam and sharpness of the pattern in which they are applied to the fiber base.

The uniform foams penetrate the surface layer of fibers but stay on the surface of the individual fibers. The foam cells break while the bonding material is on the fiber surface to form a skin of bonded fibers. The skin comprises a network of non-cardable short fibers held together by discrete binder areas with unbonded portions of fiber extending into the interior portion of the batt to stabilize the entire batt. Non-uniform foams or foams which are too wet tend to remain on the surface of the fiber assembly and penetrate the fiber assembly by saturating individual fibers which not only increases fiber density of the assembly but also forms a sticky and tacky mass which will adhere to the foam-applying means.

As previously mentioned the adhesive bonding material may be applied to the base assembly of fibers uniformly over the entire surface or in a predetermined pattern of spaced bonding areas such as continuous or discontinuous straight or wavy lines, circles, annuli, rectangles, squares, diamonds, triangles, ovals or irregular shapes. In all instances, even when the binder is uniformly applied over the entire surface, the binder is not continuous and does not form a film on the surface. The binder is discontinuous and binds fibers at their intersections and in some areas may even bridge fibers.

The amount of adhesive bonding agent required to stabilize the fiber assemblage is very small and allows the stable assemblage to maintain its porosity and absorptive characteristics yet imparts cohesive strength to the mass of fibers to the degree necessary to allow the mass to be further processed and in many instances to be used as an absorbent product without incorporating additional strengthening means.

Generally the amount of bonding material will be less than 10% based on the weight of the final product and preferably less than 5% of bonding material is used. In some instances the amount of bonding material may be reduced as low as a fraction of a per cent based on the weight of the final product.

After the bonding material has been applied to the fiber assemblage it is dried. The assemblage may be dried in air at atmospheric temperature or if desired, the temperature may be elevated from 212°F. to 450°F. or more for periods of time of from a few seconds to 5 minutes or more to accelerate the drying time. If high temperatures, 400°F. or more, are used in the drying operation the times must be short to avoid discoloration of the wood pulp or other fibrous material. In those instances when a self-cross-linking resin is used as the bonding material or if a cross-linking agent is added to the bonding material the drying step is also a curing step for the cross-linking reaction and generally elevated temperatures will be required.

The starting batts of non-cardable short fibers have a thickness of from 1/16 inch to a couple of inches or more. The starting batt is lightly compressed to press down loose surface fibers prior to foam bonding material being applied to the surface and may in some instances be lightly compressed a second time when foam bonding material is being applied. The density of the starting batt will vary from 0.05 grams/cc. to 0.07 grams/cc. or more. The thickness of the final products will vary to the same extent as the starting batts, i.e., from 1/16 inch to a couple of inches or more and preferably from 3/32 inch to 1 inch. The specific thickness of each product will depend to a large extent on its proposed end use, for example, when used as a diaper thicknesses of from 1/8 inch to 3/16 inch have been found suitable while when used as a sanitary napkin thicknesses of from 1/4 to 1/2 inch have been found suitable.

The non-cardable short-fiber batts while having good fluid-absorption properties have poor fluid-distribution properties, i.e. fluid absorbed is transmitted equally through the batt and along the batt and hence full utilization of the absorbent capacity of the entire batt is not realized. Fluid distribution along the batt may be improved by placing in the batt densified areas or compacted areas which have much greater fluid capillarity than the uncompacted areas. If these compacted areas are patterned correctly substantially the entire batt may absorb fluids before the fluids pass through the batt. Furthermore, the compacted areas improve the overall flexibility and conformability of the batt and if positioned correctly allow the batt to be rolled up on itself.

At times it may be desirable to increase

the abrasion resistance and/or strength of the absorbent products of the present invention. This may easily be done by incorporating textile fibers, continuous filaments or other long fibers either in the batt of non-cardable short fibers or on the surface of the batt of non-cardable short fibers.

After foamed bonding material has been applied to the starting material in accordance with the present invention and allowed to dry the skin formed on the final product may vary in thickness from a fraction of one per cent of the total thickness of the product to 25% of the total thickness and preferably from 1% to 10% of the total thickness of product. Generally the skins have a thickness of from 0.001 inch to 3/8 inch and preferably from 0.01 inch to 1/16 inch. The skin thickness of a stable assemblage is not uniform over the entire surface but will vary from area to area. However, the skin is relatively strong and produces a non-linting or non-dusting surface. The stable assemblage is flexible and may be flexed to a considerable degree without breaking the skin or fibers and bonding material, i.e. the skin is strong enough so that when the assemblage is flexed the unbonded fibers are compacted rather than the skin breaking. This skin, though paper-like in thickness, is devoid of hydration bonds and therefore is soft and noiseless and does not have the customary rattle of paper.

The non-cardable short-fiber assemblages produced in accordance with the present invention are self-sustaining and may be used by themselves as absorbent products or in combination with other materials such as waterproof paper, plastic films and the like. If desired the stable assemblages may be wrapped in gauze nonwoven fabric or similar materials for use in areas where considerable strength is required or to improve the adaptability or the product to the body,

The invention will be further described in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a plan view of a batt of a stable fiber assemblage according to the invention;

FIG. 2 is an enlarged cross-sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a plan view of a batt of a modified form of a stable fiber assemblage according to the invention;

FIG. 4 is an enlarged cross-sectional view taken along line 4—4 of FIG. 3;

FIG. 5 is a photomicrograph of a batt of a stable fiber assemblage according to one embodiment of the present invention;

FIG. 6 is a photomicrograph of a portion of the batt of FIG. 5 to a larger scale;

FIG. 7 is a photomicrograph of a cross-section of the batt of FIG. 5;

FIG. 8 is a photomicrograph of a batt of a stable fiber assemblage according to another embodiment of the present invention;

FIG. 9 is a photomicrograph of a cross-section of the batt of FIG. 8;

FIG. 10 is a perspective view of a batt of a stable fiber assemblage of the present invention which is intermittently bonded on one surface and bonded overall on the opposite surface;

FIG. 11 is a cross-sectional view taken along line 11—11 of FIG. 10.

FIG. 12 is a perspective view of a batt of a stable fiber assemblage of the present invention having a layer of long fibers on one surface of the batt;

FIG. 13 is a cross-sectional view taken along line 13—13 of FIG. 12;

FIG. 14 is a perspective view of a batt of a stable fiber assemblage of the present invention having a layer of long fibers between the surfaces of the batt;

FIG. 15 is a cross-sectional view taken along line 15—15 of FIG. 14;

FIG. 16 is a perspective view of an embossed batt of a stable fiber assemblage of the present invention showing one pattern of embossing;

FIG. 17 is a perspective view of an embossed batt of a stable fiber assemblage of the present invention showing another pattern of embossing;

FIG. 18 is a perspective view of an embossed batt of a stable fiber assemblage of the present invention showing still another pattern of embossing;

FIG. 19 is a perspective view of an embossed batt of a stable fiber assemblage of the present invention showing a fourth pattern of embossing;

FIG. 20 is a perspective view of a batt of a stable fiber assemblage of the present invention in combination with a waterproof backing;

FIG. 21 is an enlarged cross-sectional view taken along line 21—21 of FIG. 20;

FIG. 22 is a perspective view of a sanitary napkin embodying a batt of fibers in accordance with the present invention wrapped in a cover material;

FIG. 23 is a flow sheet diagrammatically showing processes for producing absorbent products according to the methods of the present invention;

FIG. 24 is a diagrammatic showing in elevation of an apparatus for producing absorbent products according to one method of the present invention;

FIG. 25 is a diagrammatic showing in elevation of a modification of means for applying foam bonding materials according to the methods of the present invention;

FIG. 26 is a diagrammatic showing in elevation of another modification of foam-applying means according to the present invention;

FIG. 27 is a diagrammatic showing in elevation of another modified foam-applying means;

FIG. 28 is a diagrammatic showing in elevation of a modification of the foam-applying means of FIG. 27;

FIG. 29 is a diagrammatic showing in elevation of apparatus for producing absorbent products according to the methods of the present invention;

Referring to the drawings, in FIG. 1, there is shown a stable short-fiber assemblage 31 of the invention. The stable assemblage comprises non-cardable short fibers 32 and a bonding material 33 distributed through the surface layer of fibers to form a skin 35 of fibers and bonding material on the surface of the assemblage.

The skin has a finite thickness, i.e. it has a minimum thickness of at least the thickness of an individual fiber. As is more clearly depicted in the cross-sectional view of the assemblage, FIG. 2 the bonding material extends through the surface layer of fibers but does not extend completely through the assemblage. Unbonded portions of fibers which generally lie in the surface layer extend downwardly into the assemblage in frictional engagement with unbonded fibers of the assemblage to stabilize the entire assemblage.

As has been pointed out before, in all cases the skin formed will not comprise more than 25 per cent of the total thickness of the product. If both surfaces of the batt are bonded to form skins on both surfaces there will be, in all instances, at least 50% of the total thickness of the product of unbonded fibers forming what is hereinafter called the interior portion of the batt.

The starting batts of non-cardable short fibers used to produce the stable assemblages of the present invention have a thickness of from 1/16 inch to two inches or more. The starting batt is lightly compressed to press down loose surface fibers prior to bonding material being applied to the surface and may in some instances be lightly compressed a second time when bonding material is being applied. The density of the starting batt will vary from 0.05 grams/cc. to 0.07 grams/cc. or more. The thickness of the products of the present invention will vary to the same extent as the starting batts, i.e., from 1/16 inch to two inches or more and preferably from 3/32 inch to 1 inch. The specific thickness of each product will depend to a large extent on its proposed end use, for example, when used as a diaper, thicknesses of from 1/8 inch to 3/16 inches have been found suitable while when used as a sanitary napkin, thicknesses of from 1/4 inch to 1/2 inch have been found suitable.

In FIG. 3 there is shown a stable non-cardable short-fiber assembly 36 wherein the bonding material has been applied in the predetermined pattern of dots 37 over the surface of the assembly. The cross-sectional view, FIG. 4 of the assembly shows that the bonding material extends through the surface layer of fibers to form a skin 38 of fibers and patterned bonding material and that unbonded portions of the fibers which generally lie in the skin extend downwardly into the assembly whereby the entire assemblage of short fibers is stabilized.

The assemblage of FIG. 5 contains non-cardable short fibers held together by a predetermined pattern of dots. FIG. 6 is an enlargement of one of the bonding-material dots of FIG. 5 showing the fibers within the bonding area partially coated with bonding material. As may be seen in the cross-sectional picture, FIG. 7, the bonding material extends through the surface layer of fibers to form a skin on the surface of the assemblage but does not extend through the entire thickness of the fiber assemblage. The major portion, i.e. the interior portion of the fiber assemblage comprises unbonded short fibers and the assemblage has a surface layer of bonded fibers which forms a skin about the entire assemblage. Portions of fibers extend from this skin into the assemblage and are in frictional engagement and mechanical entanglement with the fibers in the interior portion of the assemblage whereby the entire assemblage is stabilized.

The fabric of FIG. 8 and FIG. 9 contains non-cardable short fibers held together by a bonding material distributed over the entire surface of the fiber assemblage to form a skin encompassing the assemblage.

In FIGS. 10 and 11 there is shown an absorbent product 40 of the present invention having one surface 41 bonded in a predetermined pattern of dots 42 and the opposite surface 43 uniformly bonded over the entire surface. The interior portion 46 is free of adhesive bonding material. The longitudinal edges 44 and 45 of the product are compressed to seal the edges and prevent fiber separation at the edges of the product. If desired, a water repellent such as silicone may be included with the bonding material which is applied on the overall bonded surface to make this surface water-repellent.

In FIGS. 12 and 13 there is shown an absorbent product 48 of the present invention comprising a batt of non-cardable short fibers 49 having a layer of continuous filaments 50 on one surface. The batt of fibers and filaments is bonded on the surface to form a skin 51. The opposite surface is also bonded to form a skin 59 of short fibers and a bonding material. The edges 52 and 53 are compressed to prevent fiber separation at the edges. The surface layer of filaments improves the abrasion resistance of the product and also increases the strength of the product. In

FIGS. 14 and 15 the batt 54 of fibers has a layer of continuous filaments 55 in the center of the batt. The surfaces are bonded to form a skin 56 and the edges 57 and 58 have been compressed to prevent fiber separation at the edges. The intermediate layer of filaments improves the strength of the final product.

In FIGS. 16 to 19 there are shown absorbent products of the present invention which have been compacted in different patterns to improve the fluid capacity and the flexibility of the absorbent product.

In FIG. 16 the absorbent product 60 comprises non-cardable short fibers 61 and a surface skin 62 of short fibers and bonding material. The product has lines 63 running the length of the product which are compacted. In FIG. 17 the absorbent product has lines 64 running across the product which are compacted. In FIG. 18 the compacted areas comprise lines 63 and lines 64 running along and across the product respectively to form squares of uncompacted areas. In FIG. 19 the transverse lines 65 are broken to prevent fluids from running to the very edge of the product and causing leakage. In many instances only a portion of the surface of the base assembly may have adhesive bonding material applied to it. This is especitrue when the stable assemblage is to be laminated or otherwise covered with other material such as plastic films or waterproof paper. For example, as shown in FIGS. 20 and 21, a sheet of short fibers 66 has adhesive bonding material 67 applied to one outer surface in accordance with the present invention to stabilize the short-fiber sheet. The other side of the stable fiber sheet is laminated to a thin water-proof film 68 and sealed at the edges 69 by heat to produce an inexpensive absorbent product with a waterproof backing suitable for use as a disposable diaper or sanitary napkin. Another method of waterproofing the surface of the fiber assembly is to add a water repellent such as a silicone to the bonding material and apply the bonding material containing the water repellent on to one surface of the fiber assembly.

In FIG. 22 there is shown a stable fiber assemblage 70 of the present invention wrapped in a piece of gauze cover material 71. The cover material extends past both ends of the stable assemblage to form pinning tabs 72 so that the combination may be used as a sanitary napkin. The stable assemblage is the absorbent medium in the napkin and the gauze wrapper adds strength to the napkin and allows it to be secured in position by means of the pinning tabs.

In carrying the invention into practice, we may start with loose, non-cardable short fibers (Box 101, FIG. 23) which are laid down in the form of a batt of fibers on a carrier and the batt lightly compressed (Box 102) to prevent air current from disrupting fiber arrangement in the batt. If desired, the batt may be further compressed (Box 102a) to produce pattern areas of increased density in the batt. The pattern may be as shown in any of Figs. 16 to 19 or in other desired patterns or the batt may be compressed only along its longitudinal edges to seal the edges and prevent fiber separation in these areas. An adhesive bonding material (Box 103) is foamed (Box 104) and placed on a moving surface (Box 105). The fluffy batt is moved into proximity to the surface carrying the foam material (Box 106) and the foam transferred to the surface of the fluffy batt. The fluffy batt with the bonding material in the surface of the batt is dried (Box 107) to form a stable assemblage of short fibers.

FIG. 24 illustrates one method of carrying out the invention on a continuous production-line bases. A batt 125 of unbonded, loose and fluffy wood pulp fibers is fed on a conveyor belt 126 which passes over a supporting roller 127. Spaced above the supporting roller is a foam bonding mechanism 128 which is a roll coater 129 about which an endless screen belt passes. The wood pulp passes between the supporting roll and the roll coater and foam bonding material 131 is continuously deposited on the roll coater which in turn deposits the foam on the surface of the wood pulp. The endless screen belt prevents the wood pulp with the foam bonding material on its surface from sticking to the surface of the roll. In FIG. 25 another mechanism for applying foam bonding material is shown which comprises an embossed roll 135 to which foam bonding material 136 is applied. A doctor blade 137 controls the amount of foam material carried by the embossed roll. The surface of the embossed roll has a raised diamond pattern over its entire surface. The bonding material is applied to the embossed surface and is deposited from the roll surface on to the surface of the wood pulp sheet 138. The sheet is supported on a conveyor 139 and is backed by a support roller 140 as the foam material is applied. In both the embossed diamond roll and the roll coater the bonding material, though being deposited in an overall pattern on the surface of the fiber sheet, is not continuous but is in a discontinuous overall pattern.

Still another foam-applying mechanism is shown in FIG. 26. A fibrous batt 143 is placed on a conveyor 144 and passed beneath a continuous screen-belt conveyor 145. Spaced above the screen-belt conveyor is a roll-coater 146. Foam bonding material 147 is fed to the nip formed by the roll-coater and the screen-belt conveyor and the foam passed through the screen-belt conveyor onto the surface of the batt. Roller 148 supports the batt as the foam bonding material is being applied.

Depending on the pattern used in the em-

bossing roll depicted in FIG. 25 and on the openness of weave of the screen-belt conveyor in FIG. 26 these mechanisms may be used to apply foam bonding material either as an overall coating or in a predetermined pattern of spaced binder areas. However, we prefer when applying a predetermined pattern of foamed bonding material to use the mechanisms depicted in FIGS. 27 and 28.

In FIG. 27 the fibrous batt 150 is placed on a conveyor 151. The conveyor and batt pass beneath a perforated drum 152 with the surface of the batt contacting the outer surface of the drum. The perforated drum rotates in the same direction that the non-cardable, short-fiber batt is moving and without relative translatory motion between the batt and drum. The foamed bonding material 153 is applied to the batt through the perforations of the drum using the inner roller shown inside drum 152 to press foam bonding material through the perforations and allow for the continuous production of the bonded fibrous batt. If desired, the smooth back-up member 155 shown in FIG. 27 may be replaced with a flexible belt 156 as shown in FIG. 28. The belt 156 is placed under tension by pressure applied from the perforated drum 152. This tension keeps the fiber batt in intimate contact with the perforated drum and improves the control of the amount of bonding material applied to the sheet and also the uniformity of binder application. The intimate contact of the perforated drum with the batt also improves the sharpness of the pattern of bonding material and makes the individual areas of bonding material more definitive.

After the foamed bonding material has been applied to the non-cardable short-fiber batt the foam cells break or disintegrate and the adhesive bonding material coats the outer layer of fibers. The batt with the bonding material in its surface is then passed through a drying operation such as the infra-red drying oven 157 shown in FIG. 24 to form a stable fiber assemblage.

In many end uses for the stable fiber assemblages of the present invention it will be desired that both sides of the unbonded wood-pulp sheet be covered with adhesive bonding material. This of course may be done simply by turning over the bonded wood pulp sheet as produced by the process outlined above and passing it again through a mechanism described in conjunction with FIGS. 23 to 28. Whatever the manner of application of the bonding agent, penetration thereof is limited to the surface or surfaces of the batt.

Referring to FIG. 29 there is shown apparatus for continuously producing stable fiber assemblages having their opposite surfaces coated with adhesive bonding material. Wood-pulp board 160 is fed to a hammer mill 161 to grind the board and deposit the loose, fluffy, wood-pulp fiber 162 on an endless conveyor 163. The loose fiber batt or pulp ribbon, as it is commonly called in this stage, is passed between two compression rolls 164 to produce a wood-pulp batt 165. The compression rolls lightly compress the batt. If desired they may be patterned to compress the batt lightly and compress the edges of the batt highly and/or compress the batt heavily in a pattern of areas to improve fluid capillarity of the final product as previously described. The compressed batt is passed between two endless scren-belt conveyors 166 moving without relative translatory motion between the conveyors and the wood-pulp batt. The conveyors lightly contact opposite surfaces of the wood-pulp sheet and support it while foamed bonding material 167 is being applied. Both endless conveyors pass over foam-applying rolls 168 and 169 at the same time so that the opposite foam-applying rolls act as back-up rolls for each other. The foamed bonding material is continuously fed to the surface of the foam-applying rolls and squeezed through the endless screen-belt conveyor onto the surface of the wood-pulp sheet. The surface-coated wood-pulp sheet is placed on another conveyor 170 and dried by passing it through an infra-red drying oven 171 or other suitable drying means to produce a stable fiber assemblage 172.

The invention will be further illustrated in greater detail by the specific examples. The percentages are by weight unless otherwise indicated.

EXAMPLE I

Pine-wood pulp in the form of a highly compressed pulpboard about 5 inches wide and 1/10 inch thick is ground in a hammer mill to form a pulp ribbon of fluffy, loose fibers. The ribbon is approximately 2—3/4 inches wide and about 3/4 inch thick and weighs about 45 grams per square foot. The ribbon is passed between compression rolls and slightly compressed. The pulp ribbon is placed on the conveyor 126 of the apparatus illustrated in FIG. 24. The conveyor with the pulp ribbon thereon passes between the nip formed by the supporting roller 127 and the bonding mechanism.

To the bonding mechanisms there is continuously fed a foamed bonding material 131 produced from an aqueous emulsion having the following composition: 4.6% of polymer of ethyl acrylate, acrylamide and acrylic acid, 1% of a polyether alcohol surface-active agent sold as "Triton X-100", 4.5% of ammonium chloride catalyst to aid in the cross-linking of the acid and amide groups of the acrylate polymer and the remainder water. (The word "Triton" is a registered Trade Mark).

The foam bonding material is applied to the pulp ribbon in an over-all coating and in an amount of about 1.0 gram per square foot on a dry basis.

The pulp ribbon with the bonding material on one surface is then passed through an infra-red oven 157 at a temperature of about 450°F. The time in the oven is about 30 seconds and the bonded ribbon has the water driven off, and the bonding material cured and dried.

The pulp ribbon having one side bonded is turned over and the second or unbonded side treated in the same manner.

The original pulp ribbon is not self-sustaining but falls apart and fibers readily dust or lint from the ribbon, but when bonded as described above, it has considerable cohesive strength, substantially no fiber separation and may be used as an absorbent bandage, sanitary napkin, or the like. The bonded ribbon retains the excellent absorption characteristics of fluffed wood pulp and is very soft.

EXAMPLE II

A hardwood pulp in the form of a highly compressed pulp board about 5 inches wide and 1/8 inch thick is ground in a hammer mill to form a pulp ribbon of fluffy, loose fibers. The pulp ribbon is 6 inches wide and about 1/4 inch thick and weighs about 24 grams per square foot. The ribbon is passed between compression rolls and slightly compressed. The ribbon is passed between a back-up roll and a drum perforated as illustrated in FIG. 27. The drum has 233 holes per square inch. The holes are 0.040 inch in diameter and are aligned both along and across the plate. The plate has an open area of 30%.

The liquid bonding material which is foamed prior to applying it to the fibrous batt has a composition of 5% of a polyvinyl chloride polymer, 2% of an alkyl sulfo-amide sold under the Registered Trade Mark "Igepon" by the General Aniline and Film Corporation with the remainder water. The foam has an average cell size of about 1/80th of an inch in diameter.

The foam penetrates through the perforations in the drum and onto the surface of the pulp ribbon to form a pattern of spaced dots of bonding material on the surface of the ribbon. The bonded batt is turned over and bonding material applied to the opposite surface in a manner similar to that previously described. The amount of bonding material applied is about 0.3 grams per square foot on each surface or a total of 0.6 grams per square foot.

The ribbon with the bonding material thereon is passed through an infra-red oven at a temperature of 220°F. The time in the oven is about 1 minute. The elevated temperature drives off the water and dries the ribbon.

The bonded ribbon has considerable cohesive strength, substantially no fiber separation, is self-sustaining, highly absorbent and has a very soft hand. It is suitable for use as an absorbent dressing or absorbent underpad.

EXAMPLE III

A hardwood pulp in the form of a highly compressed pulpboard about 5 inches wide and 1/10 inch thick is ground in a hammer mill to form a pulp ribbon of fluffy, loose fibers less than 1/4 inch in length. The pulp ribbon is 2-3/4 inches wide and about 3/4 inch thick and weighs about 45 grams per square foot and is laid down on the conveyor 163 as depicted in FIG. 29. The ribbon is passed between compression rolls and slightly compressed and the fibers entangle and entwine to hold the ribbon together loosely by slight frictional entanglement. The edges of the ribbon are highly compressed at the same time to seal the edges. The ribbon is passed between two endless screen conveyor belts 166 as illustrated in FIG. 29.

Foamed bonding materials are continuously fed to the surface of both conveyors as depicted in FIG. 29. The bonding material has a composition of 5% of a polyvinyl chloride polymer, 2% of an alkyl sulfo-amide sold under the Registered Trade Mark "Igepon" by the General Aniline and Film Corporation with the remainder water. The foam has an air-to-liquid ratio of about 10 to 1 and an average cell size of about 1/80th of an inch in diameter.

The foam penetrates through the openings in the conveyors and onto the surfaces of the pulp ribbon. The amount of bonding material applied is about 1.0 gram per square foot on each surface or a total of 2.0 grams per square foot.

The ribbon with the bonding material thereon is passed through an infra-red oven at a temperature of 450°F. The time in the oven is about 30 seconds. The elevated temperature drives off the water and dries the ribbon.

The bonded ribbon has considerable cohesive strength, is self-sustaining, highly absorbent and has a very soft hand. It is suitable for use as an absorbent dressing.

EXAMPLE IV

A layer of cotton linters having an average fiber length of 1/4 inch is laid down 14 inches wide and 1/8 inch thick and weighs about 10 grams per square foot. One surface of the cotton linter layer is treated with the apparatus illustrated in Fig. 24 and as described in Example I, is dried as described in Example I, turned over and foamed bonding material placed on the opposite surface by the perforated drum apparatus illustrated in FIG. 28. The perforated drum has 233 perforations per square inch having a diameter of 0.040 inch. The perforations are aligned in two directions and the total open area of the drum is 30%. The drum rotates

in the same direction as that in which the layer is moving and without relative translatory motion therebetween.

The liquid bonding material has the following composition: 8% of a polyvinyl acetate polymer, 2.5% of a sodium lauryl sulfate surface-active agent sold by E. I. DuPont de Nemours and Company under the trade name "Duponal" and the remainder water. The liquid is foamed at a ratio of about 10 parts air to 1 part liquid. The foam produced has an average cell size of about 1/50 of an inch diameter. As shown in FIG. 28 the foamed bonding material passes through the perforations of the drum onto the surface of the cotton linter layer to form a pattern of spaced dots of binding material. The total amount of bonding material applied to the surface is about 0.3 grams per square foot.

The layer is passed through an oven at 300°F. to drive off the water and dry the layer.

The bonded sheet is suitable for use as a disposable diaper pad.

WHAT WE CLAIM IS:—

1. A unitary, fluid-absorbent product comprising a fluffy batt of randomly arranged, intermingled and mechanically inter-engaged non-cardable fibers having a length not in excess of 1/4 inch, with or without longer fibers, said fluffy batt being flimsy and incapable of being handled without fiber separation in the absence of a binder, an an adhesive bonding material distributed through the fibers at one or both surface layers of the batt on the surface of individual fibers but not extending into the interior of the batt to a depth greater than 25% of the total thickness of the batt, thereby converting the respective surface fibers into a relatively strong skin comprising discontinuous binder originally applied to the batt as a foam with binder-coated fibers joined by binder at their intersections, said skin being mechanically locked to the unbonded interior portion of the batt by those fibers lying partially in the unbonded interior and partially in the bonded surface portions of the batt, the batt and skin thus constituting a self-sustaining, relatively strong handlable structure.

2. The fluid-absorbent product of Claim 1 wherein the adhesive bonding material is distributed in a predetermined pattern of spaced binder areas.

3. The fluid-absorbent product of Claim 1 which includes a thin layer of fibres longer than 1/4 inch on at least one surface of the batt, the bonding material being distributed in the part of the product in which it is present both throughout the short fibres and the longer fibres.

4. The fluid-absorbent product of Claims 1 or 2 wherein a layer of fibres longer than 1/4 inch is provided in the interior of the batt.

5. The fluid-absorbent product of any one of the preceding claims wherein the batt has a thickness of at least 1/16 inch.

6. The fluid-absorbent product of any one of the preceding claims wherein the adhesive bonding material comprises 0.1% to 10% based on the weight of the absorbent product.

7. The fluid-absorbent product according to any one of the preceding claims wherein the skin has a thickness of less than 25%, and preferably between 1% and 10% of the total thickness of the batt.

8. The fluid-absorbent product of any one of the preceding claims wherein the fiber layer in the skin is not densified to any substantial extent and the binder is porous throughout its surface.

9. The fluid-absorbent product of any one of the preceding claims wherein the skin is formed on one surface of the product while a water-repellent material is distributed throughout the fibers on the opposite surface but not through the interior of the batt.

10. The fluid-absorbent product of any one of Claims 1 to 8 wherein a water-repellent material is laminated to one surface of the batt whereby the batt has an absorbent surface and a water-repellent opposite surface.

11. The fluid-absorbent product according to any one of the preceding claims which is in the form of a self-sustaining sanitary napkin having compressed longitudinal edges to limit leakage of fluid and having means for attaching it to the body.

12. A method of making the fluid-absorbent product of any one of claims 1 to 11 wherein a bonding material in the form of a foam is applied to one or both surfaces of the fluffy batt in a manner to limit penetration of the bonding agent to the said surface or surfaces whereupon the bonding material is subjected to drying while in the surface of the batt.

13. The method of Claim 12 wherein the batt is placed on a moving surface while the bonding material is applied to it.

14. The method of Claims 12 and 13 wherein the foamed bonding material is placed on a moving surface and is directly transferred therefrom to the surface of the fluffy batt while the batt is moving in proximity to said surface carrying the foamed bonding material.

15. The method of Claim 14 wherein the surface carrying the foamed bonding material has a foraminous structure and the bonding material is applied through such foraminous structure.

16. The method of any one of Claims 14 or 15 wherein the surface on which the foamed bonding material is placed is a patterned surface.

17. The method of any one of Claims 14 to 16 wherein the surfaces carrying the batt and carrying the bonding material move in the same direction and without relative trans-

latory motion therebetween while the foamed material is transferred to the surface of the fluffy batt.

18. A unitary fluid-absorbent product substantially as described herein with reference to the attached drawings Fig. 1 to 22.

19. A method of making the unitary fluid-absorbent product defined in any one of claims 1 to 11, the said method being substantially as described herein with reference to the attached drawings Fig. 23 to 29.

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Fig.1.

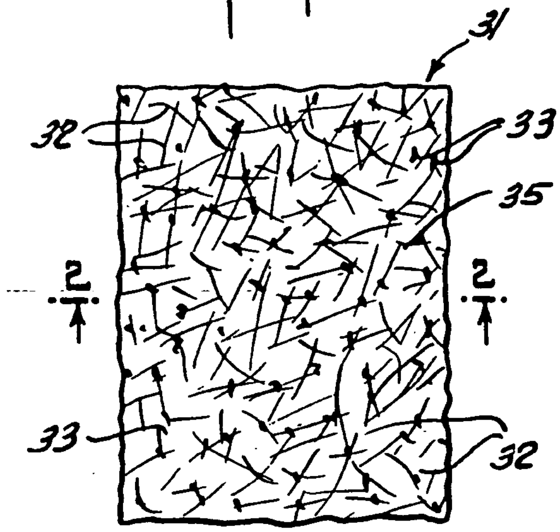


Fig.2.

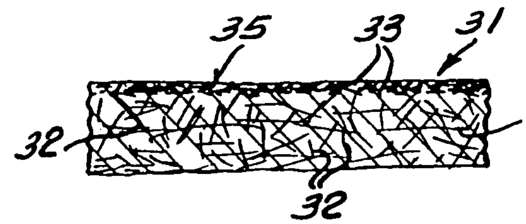


Fig.3.

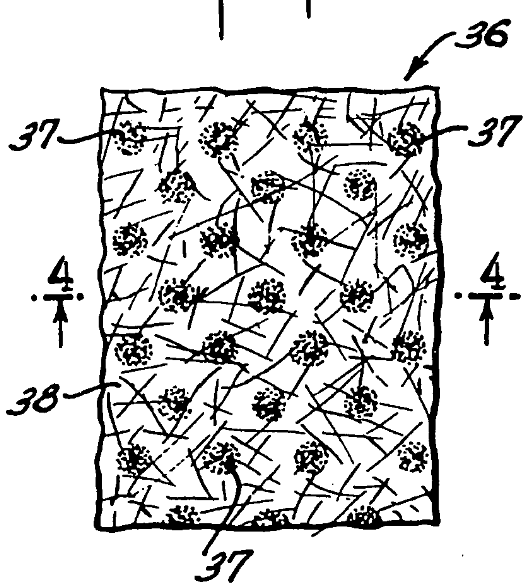
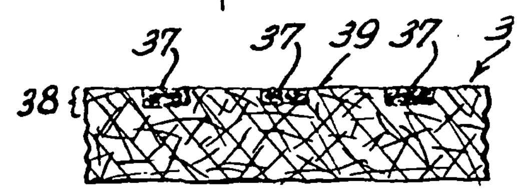


Fig.4.



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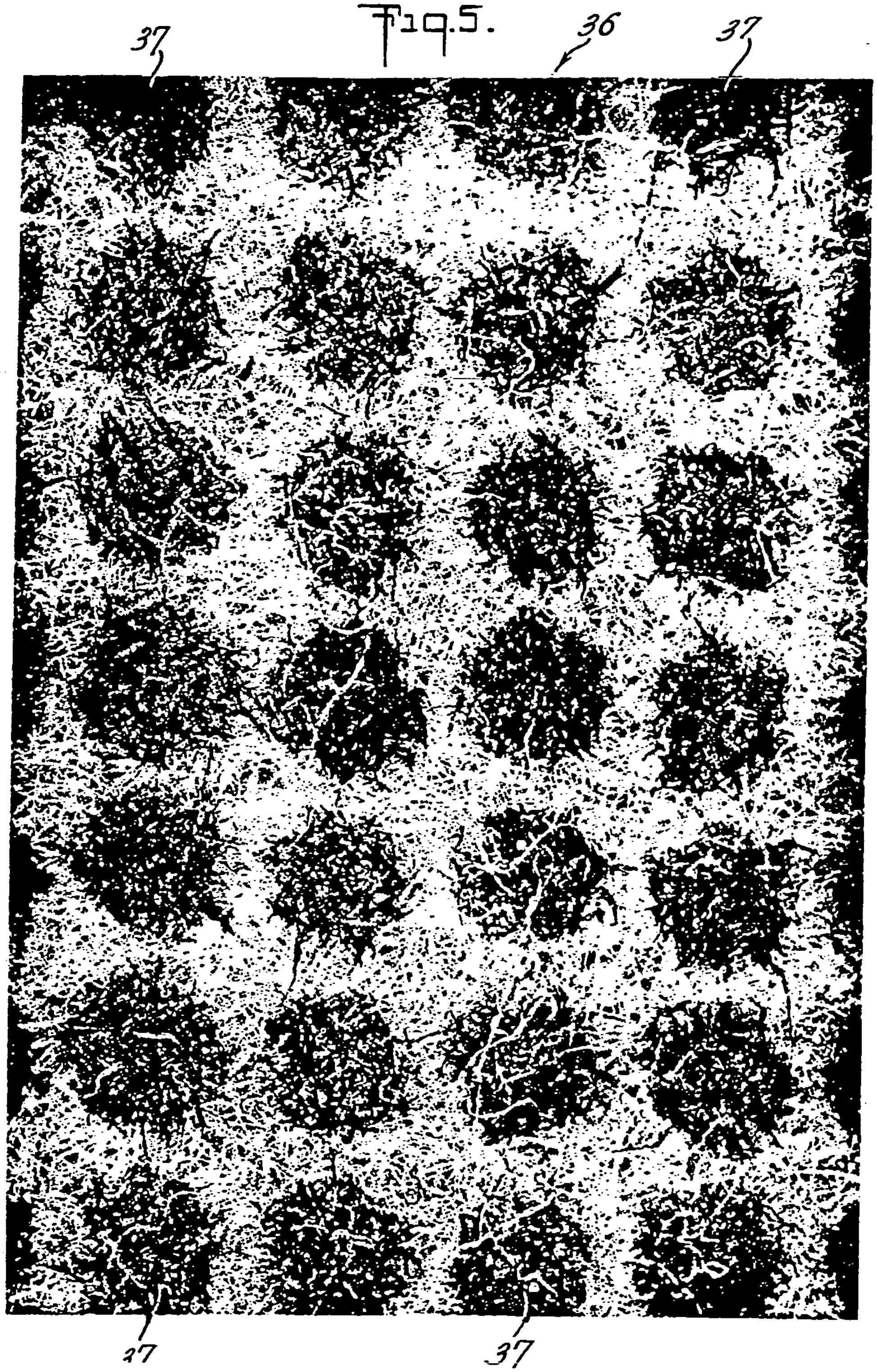
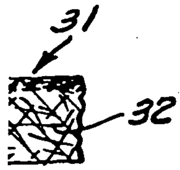
SHEETS 1 & 2

Fig.5.





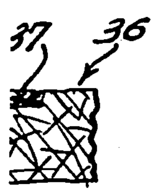


Fig.1.

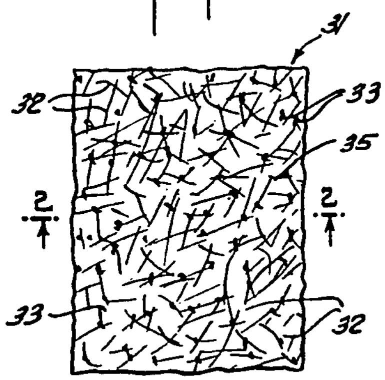


Fig.2.

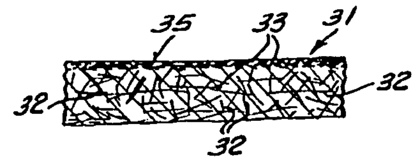


Fig.3.

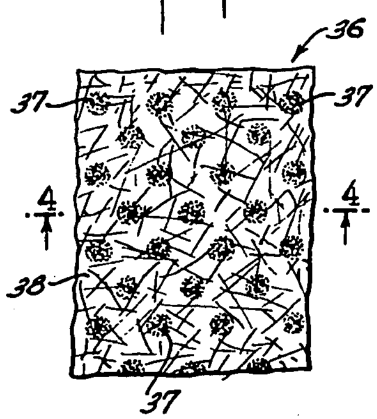


Fig.4.

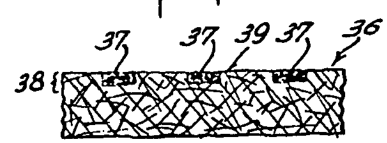


Fig.5.

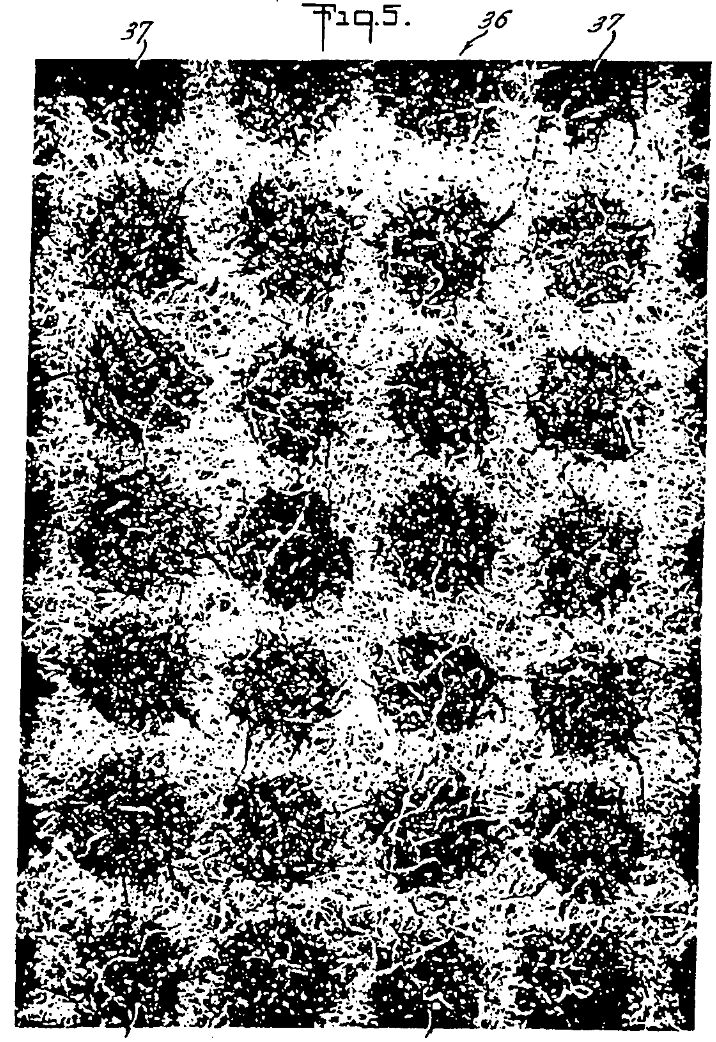


Fig. 6.

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Fig.7.

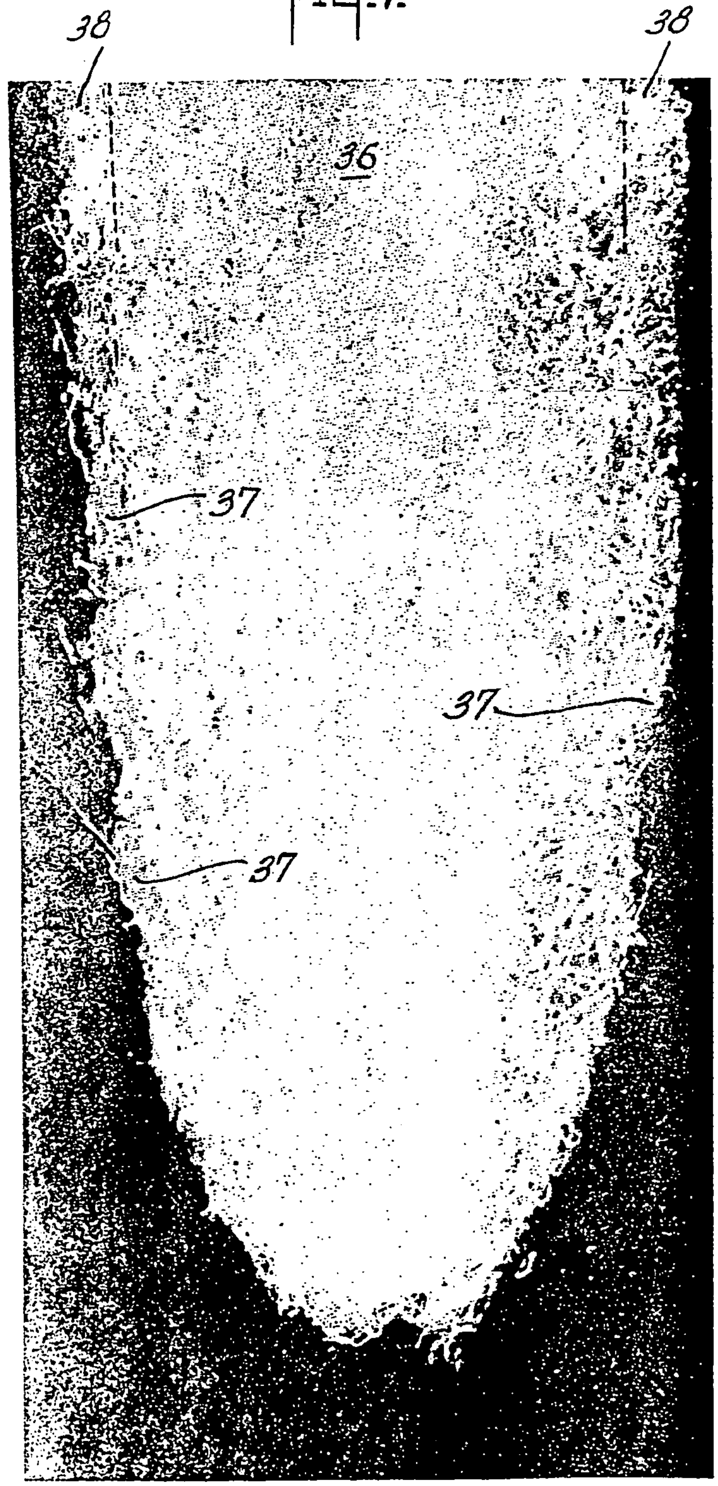

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Fig. 6.

Fig. 7.

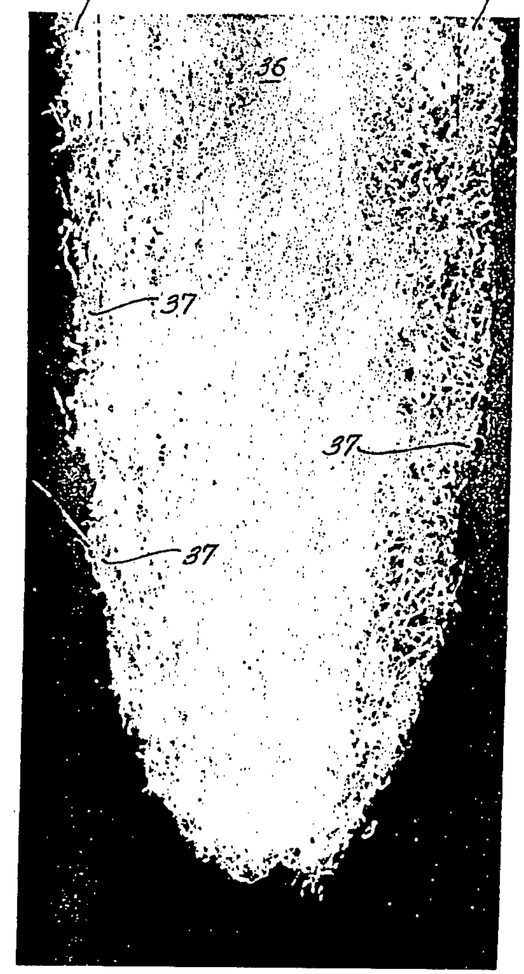

Fig. 8.

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Fig.9.

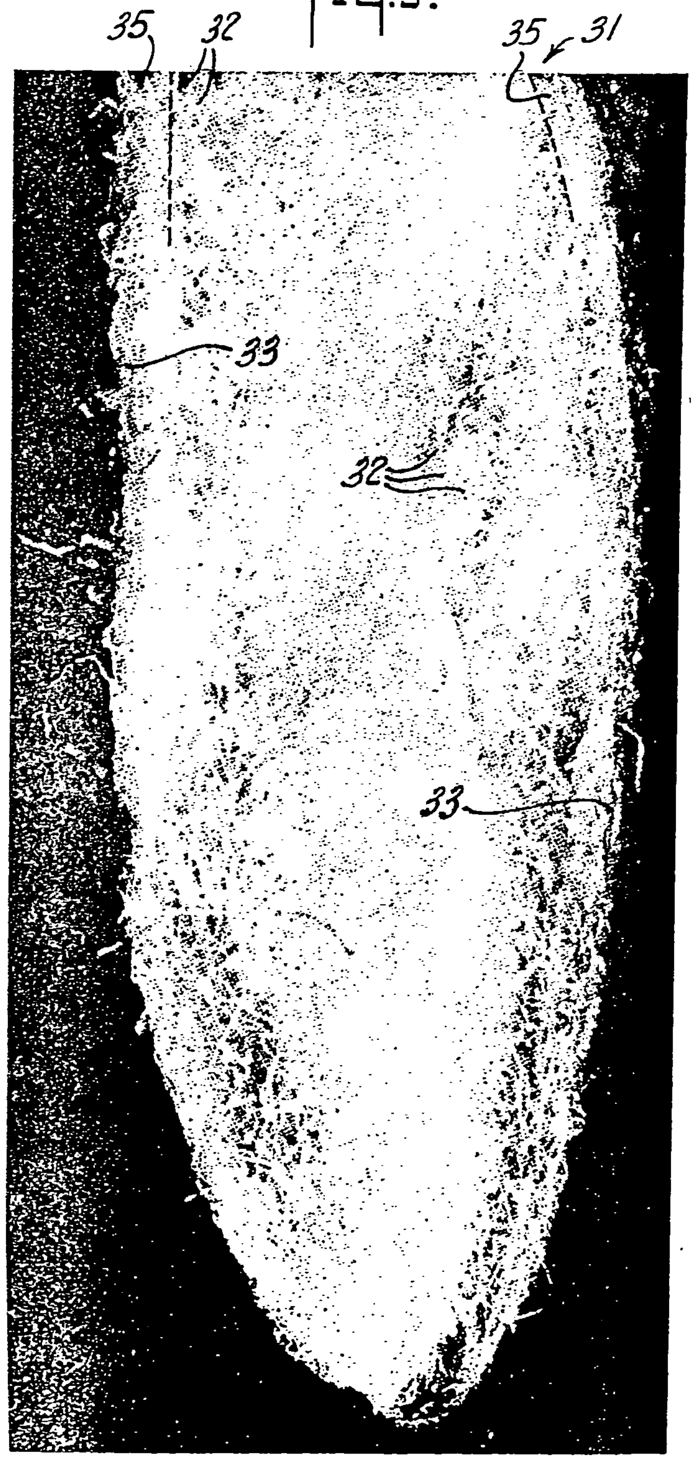

Fig.8.

Fig.9.

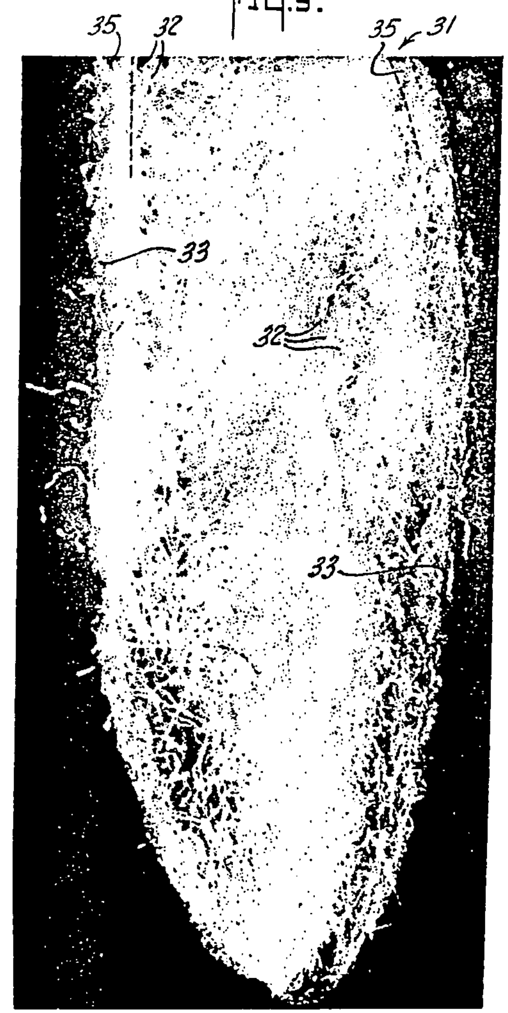

Fig.10.

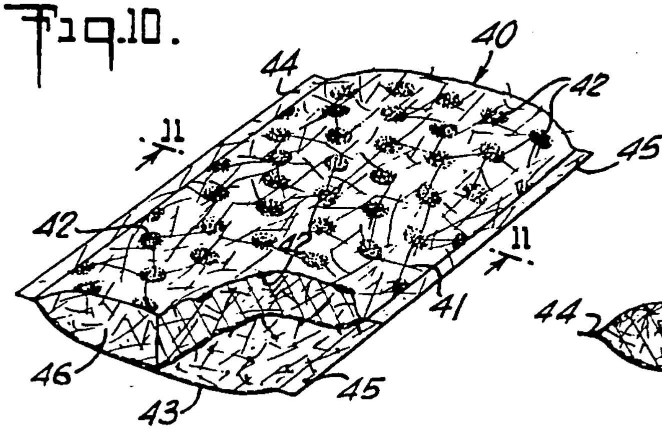

Fig.11.

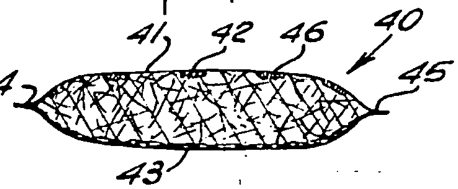

Fig.12.

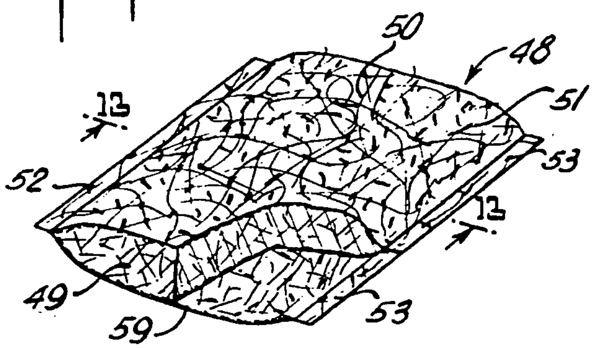

Fig.13.

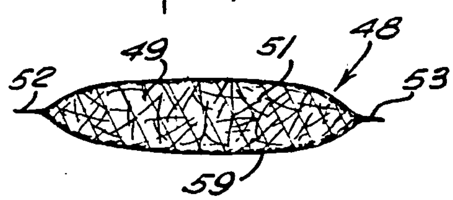

Fig.14.

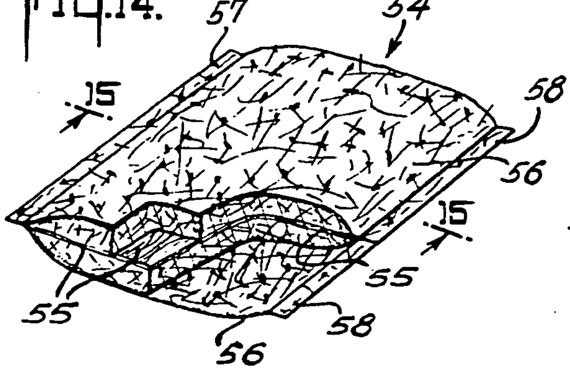

Fig.15.

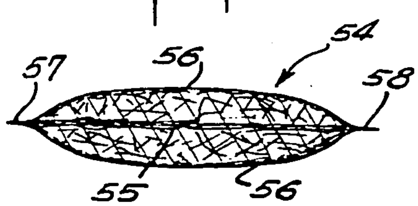

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Fig.16.

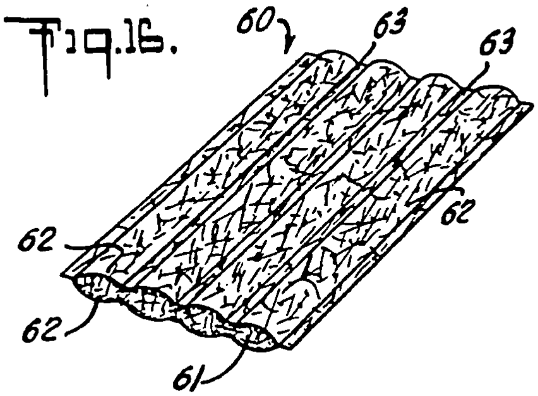

Fig.17.

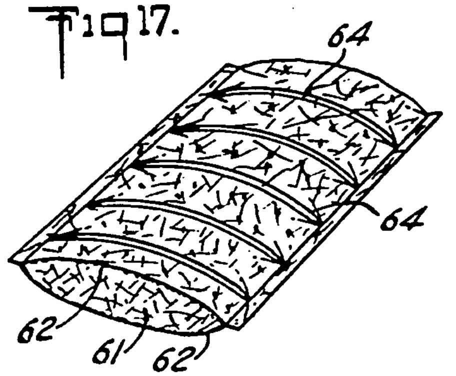

Fig.18.

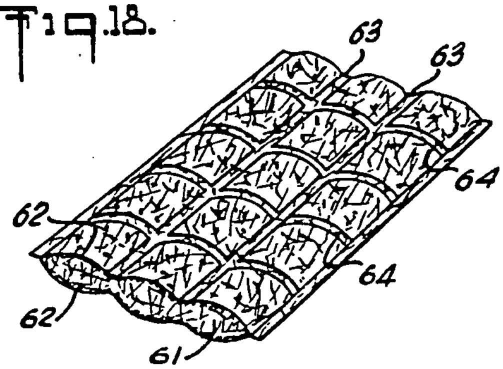

Fig.19.

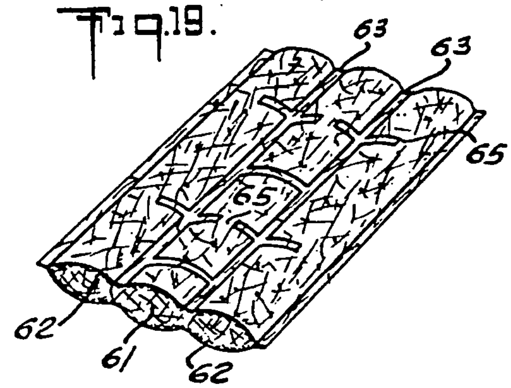

Fig.20.

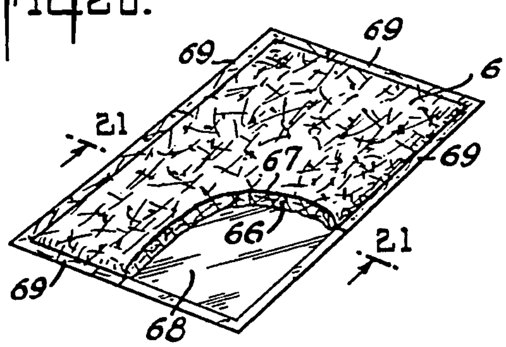

Fig.21.

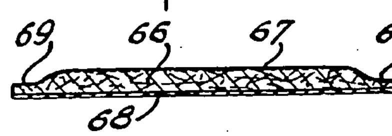

Fig.22.

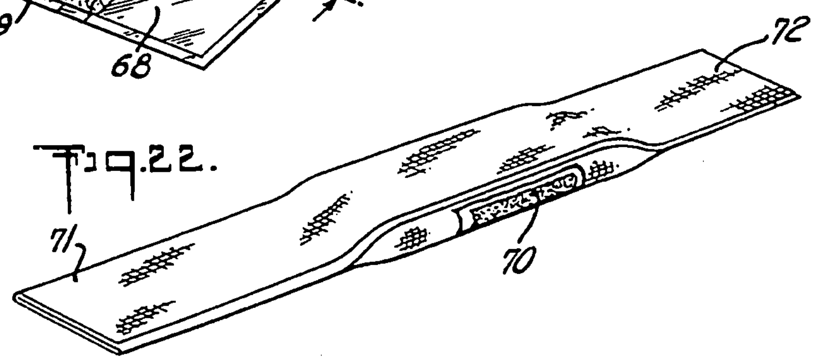

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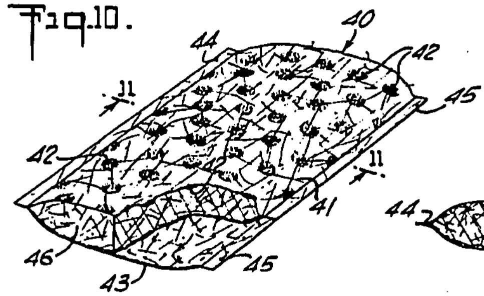
Fig.10.



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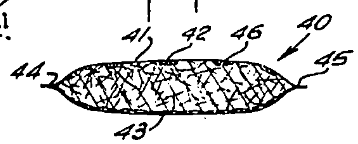

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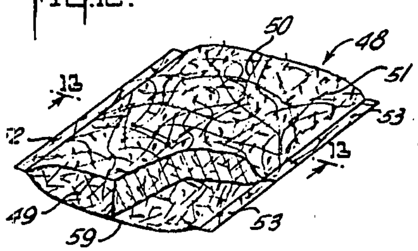

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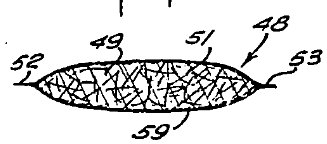

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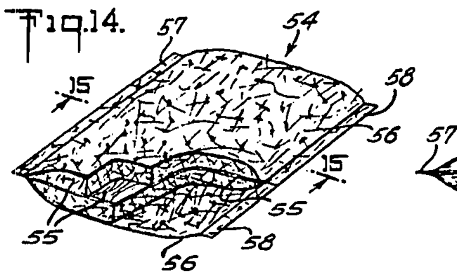

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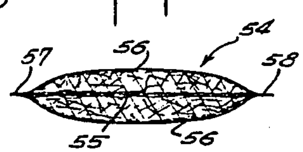

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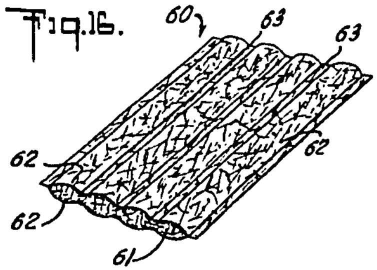

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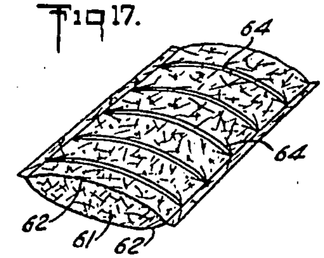

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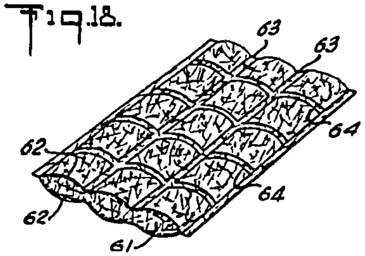

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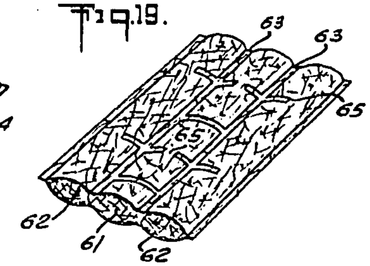

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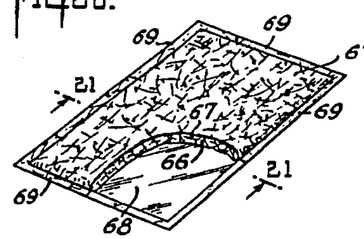

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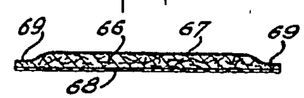

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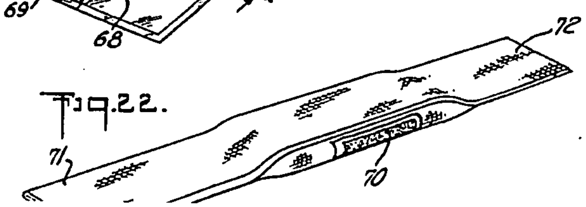

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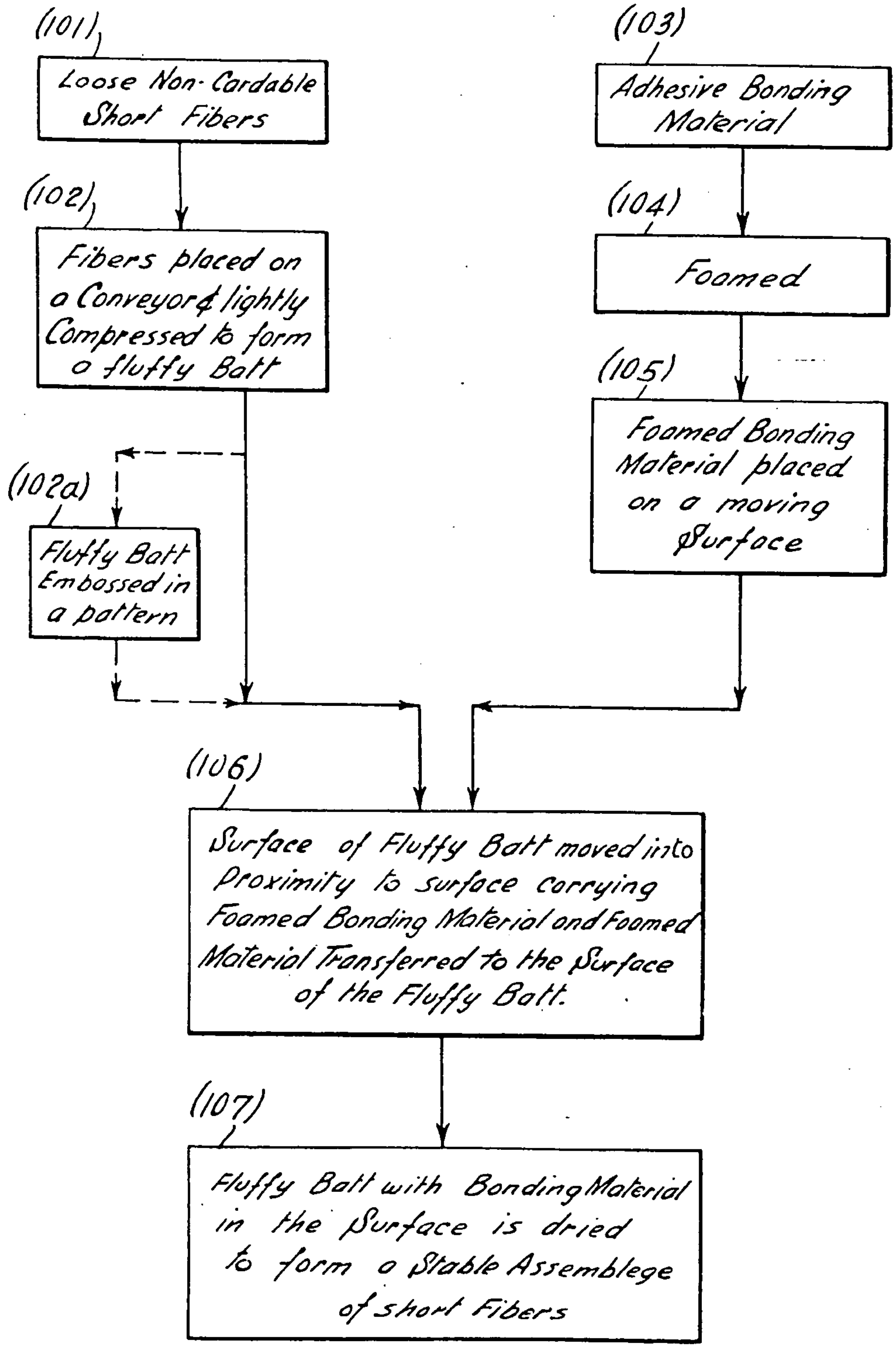

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1,071,191 COMPLETE SPECIFICATION

11 SHEETS

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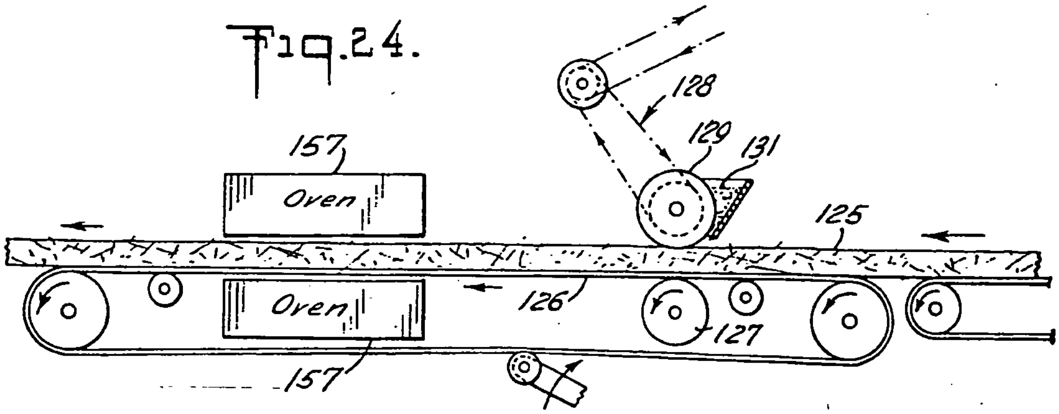
SHEETS 9 & 10

Fig.24.



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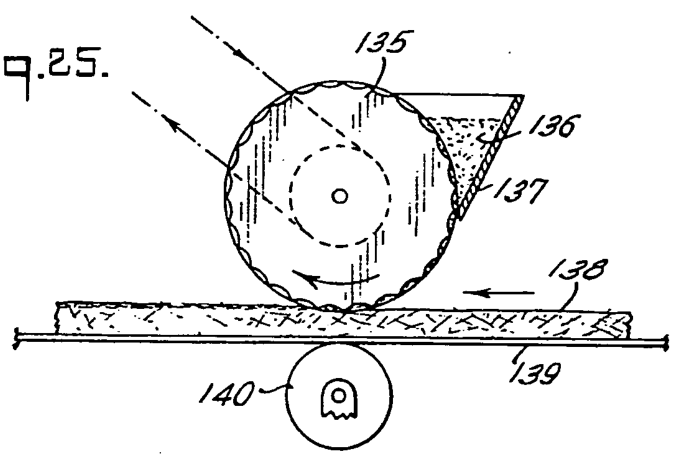

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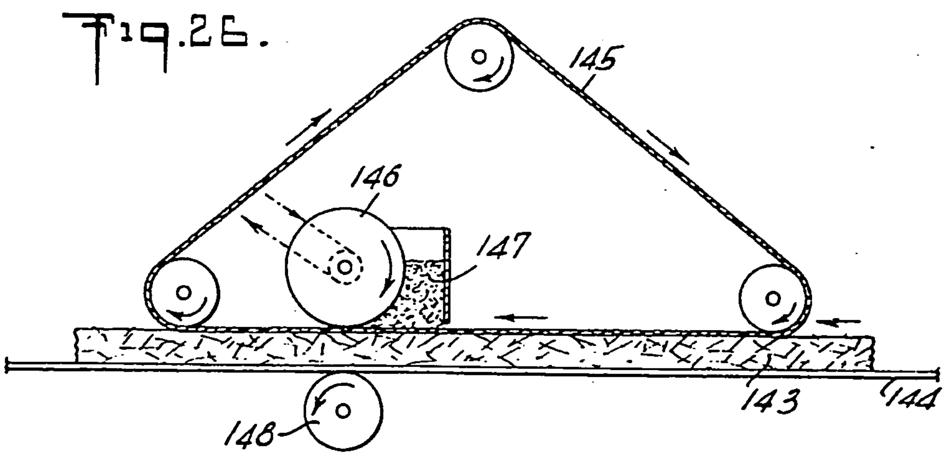

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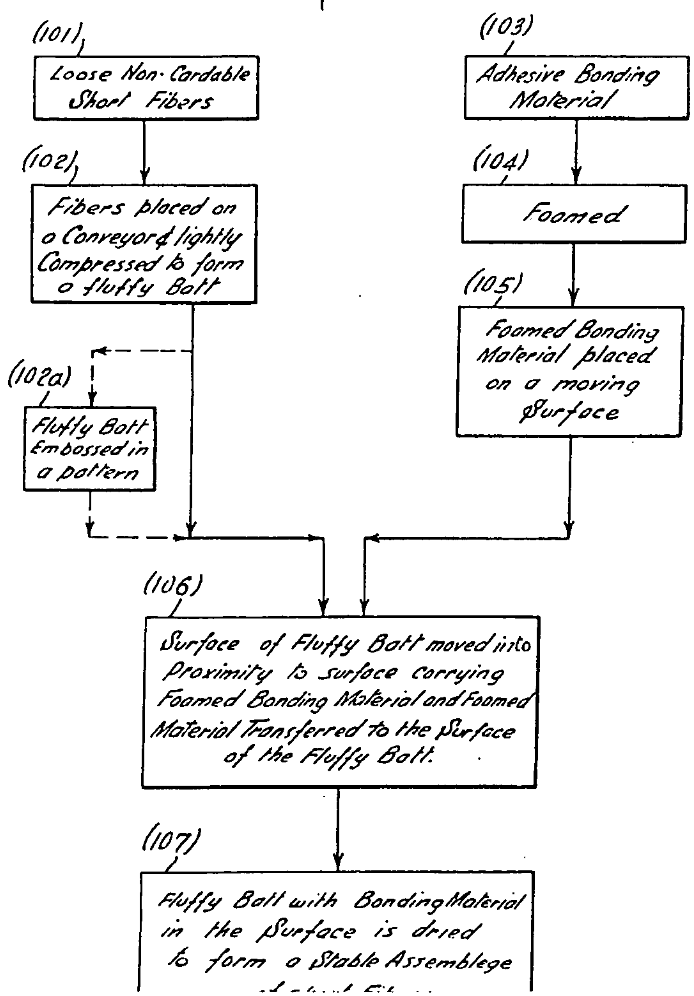

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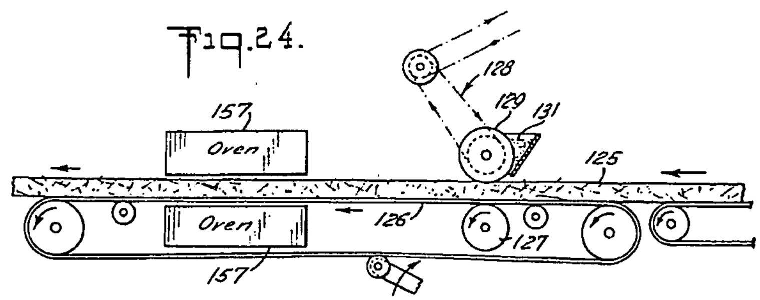

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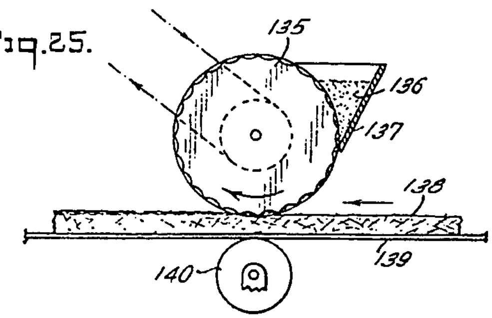

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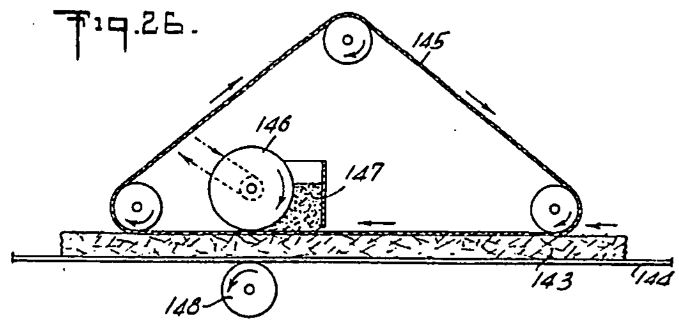

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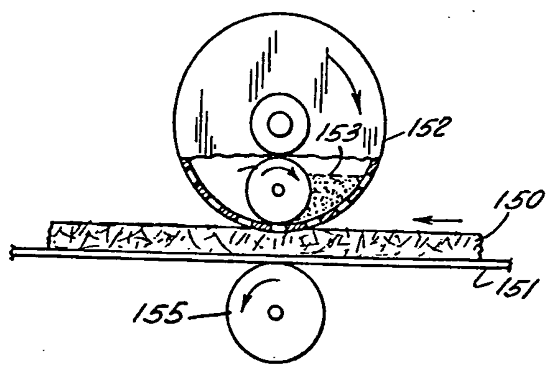

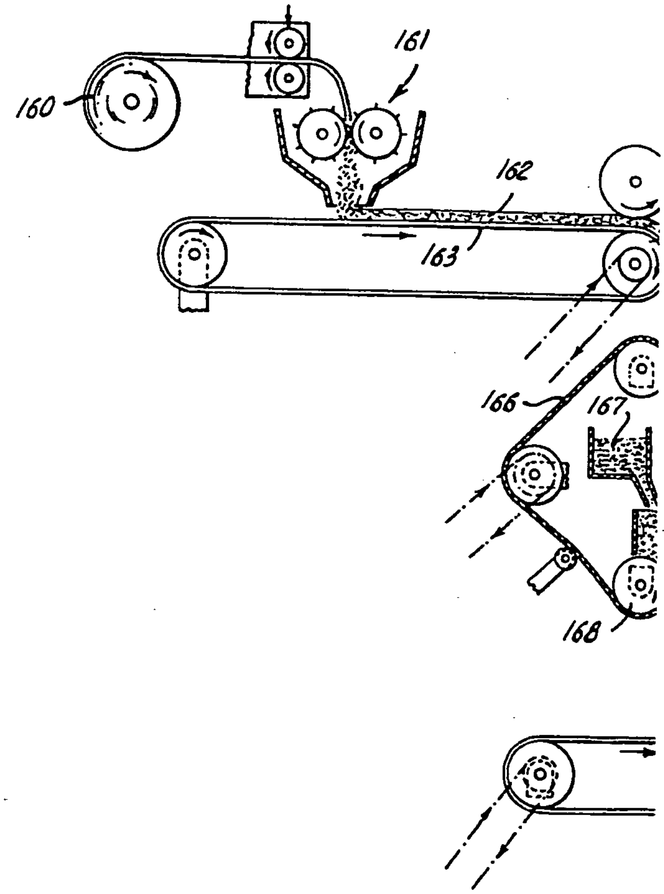

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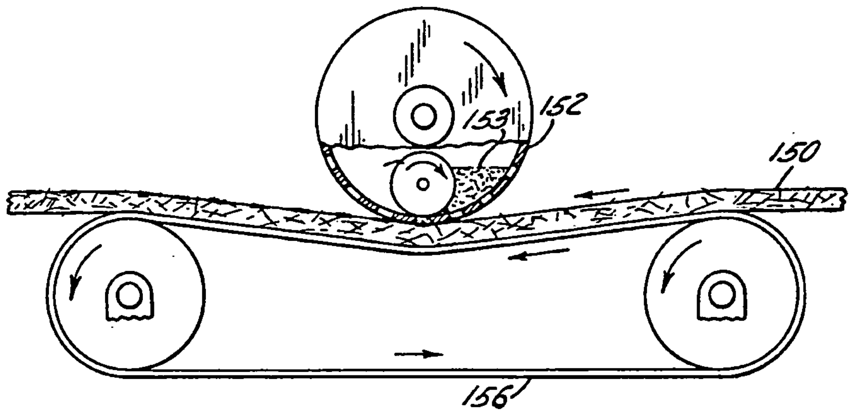
1,071,191 COMPLETE SPECIFICATION

11 SHEETS This drawing is a reproduction of the Original on a reduced scale

SHEET 11

Fig. 28.



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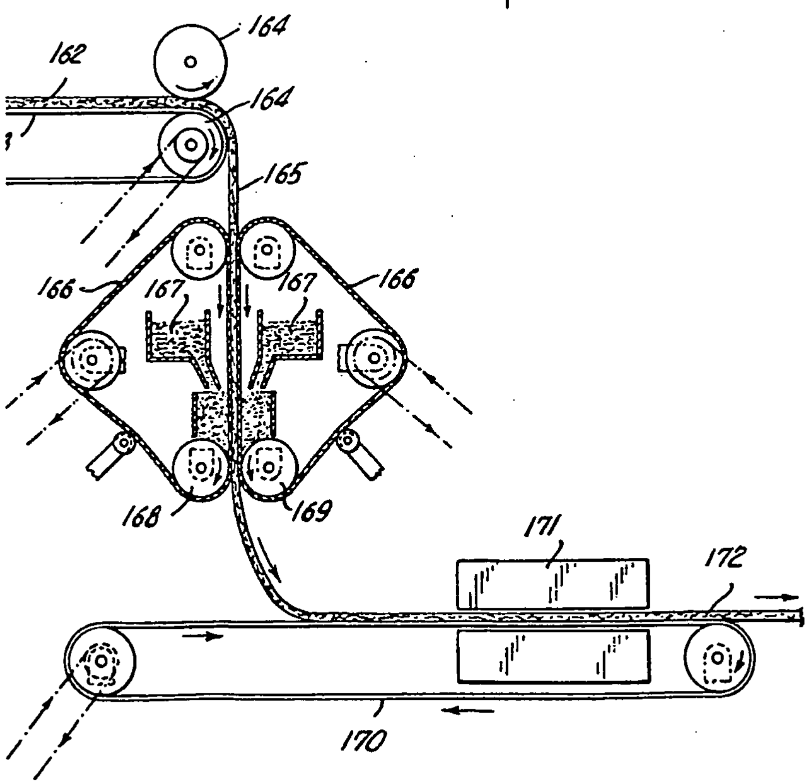

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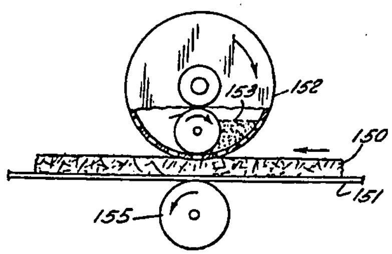

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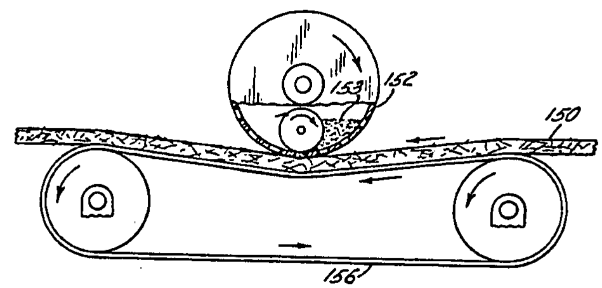

Fig.29.